Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Information Sought on Methods for Verifying Compliance with E911 Accuracy Standards	)	CC Docket No. ET 99-300
	)	
Wireless E911 Phase II Automatic Location Identification Requirements	)	DA 99-2130

To: The Office of Engineering and Technology:

COMMENTS OF OMNIPOINT TECHNOLOGIES, INC.

Omnipoint Technologies, Inc. ("OTI") hereby submits comments in response to the Commission's October 8, 1999 Public Notice, DA 99-2130 ("Notice") concerning information sought on methods for verifying compliance with E911 accuracy standards.

INTRODUCTION

The location accuracy measurement and validation process recommended by OTI is designed to specifically verify that any deployed location system meets the technical requirements of the current FCC Mandate, including the action taken by the Commission on September 15, 1999 (FCC Third Report and Order-FCC 99-240). In this sense, the recommended verification process is generic and supports location system accuracy verification for cellular (800 MHz Band) and PCS (1900 MHz Band) carriers using any of the currently proposed positioning technologies. The recommended verification process is also neutral with respect to air interfaces, e.g. AMPS, TDMA, CDMA, GSM, and iDEN. Since location accuracy performance for any location technology can vary significantly throughout a given geographical area, OTI recommends carriers sample the location accuracy over the entire deployment area within the license BTA or MTA. Then, all measurements across the area under test should be combined to arrive at an aggregate estimate of performance to which compliance is measured. The recommended verification process is cost effective and designed to account for: (1) correct handling of biased radial error measurements, (2) the FCC specified confidence levels, (3) the underlying measurement error distribution tails, (4) all operating environments (including Urban, Suburban, Rural, Indoors, Subterranean) and (5) E911 Traffic Loading. Measurement time to collect the data is minimized and presented in a convenient way for easy interpretation. All error sources are accounted for including: (1) GDOP, (2) multipath and channel fading, (3) calibration errors, (4) saturation caused by large received signal levels, (5) co-channel and adjacent channel interference, (6) time and frequency stability, (7) location algorithm limitations, (8) hardware and implementation imperfections, and (9) severe path attenuation.

Finally, we note the verification methodology is described in general terms. Achieving a detailed, objective, fair and unambiguous verification methodology requires further study of a number of technical and statistical factors, which are discussed below.

VALIDATION METHODOLOGY

The recommended validation process requires that the service (coverage) area of the deployed location system be separated into various partitioned areas. Ideally, these partitions would be based upon the distribution of mobile E911 calls in the service area. Currently, however, this data is not generally available. To alleviate this issue, we recommend the use of population density data as a readily available surrogate. Once these population-density-based partition areas are established, fixed, mobile, and hybrid-type location error measurements are taken according to a procedure described in detail later in this document. Individual measurement results are ultimately combined into a single Circular Error Probability (CEP) result, which can then be checked for compliance with the FCC mandate.

There are two mathematically equivalent approaches for obtaining the required overall CEP result. The first method is depicted in Figure 1 and employs a uniform density of measurement locations taken from candidate measurement sites established on a grid overlaying the entire coverage area. Individual CEP results are then computed for each partition area. These resulting CEPs for each partition area are then weighted by the population density of that area, and combined into a single overall CEP. The second method is depicted in Figure 2, and varies the density (number) of the measurement locations based on the population of each partition. The results of all measurements across the entire coverage area are then combined linearly into one overall CEP. Although mathematically equivalent, the second method has the advantage of focusing measurements in areas which will typically have more E911 calls, and avoids taking many measurements in areas of very low population. For these reasons, this method is hereby proposed, and will be further detailed in the sections that follow.

STATISTICAL CONSIDERATIONS

A. General Observations

Inherently, the location error from a position location system over an area is a random variable that is a complex function of time and space (location) due to the complex underlying radio environment. Other factors, such as mobile velocity and interference environment also impact the error statistics. Practically, the average performance of such a system can only be estimated by collecting samples of errors taken at representative points in each of these dimensions. The statistical testing methodology should be designed to best measure the performance of the location system under test against the E911 mandate, which is expressed as a probability of wireless 911 calls to be located to within a prescribed distance of their true position.

To accomplish this, the following general principles should be applied:

- The parameters for the measurements should be chosen to be representative of the E911 call base. This implies, for example, that the velocity of the mobiles used in the measurements should be at least roughly representative of the distribution of mobile velocity typical of wireless 911 calls

- The number of measurements per location should be determined by the statistical confidence desired

- The number and location of test sites should be chosen to provide a sufficient number of independent measurements in the spatial dimension

B. Specific Recommendations and Observations

All measurements across the area under test should be combined to arrive at an aggregate estimate of performance to which compliance is measured.

Later in this document, we propose a method for choosing test locations which reflect the underlying population. By combining measurements across the entire area under test, an estimate of the cumulative distribution of radial location error is obtained. This measured distribution approximates the true distribution of location error of E911 calls placed at points throughout the area under test. The 67 percentile and 95 percentile points on this distribution may then be compared to the specified limits to judge compliance.

No specific statistical model should be assumed of the test procedure.

A statistical model of position error may be useful in deriving parameters in the test method, but is not required for the test procedure itself. It is unlikely that a single model will adequately describe the error statistics produced by different location methods.

Considerations for outliers

The recent revision of the mandate provides statistics that are reasonable measures of performance in the presence of outliers. Provided the number of measurement trials produces adequate statistical confidence in the presence of infrequently occurring large errors, no additional measures are necessary. Testing should be allowed on more than the minimum number of points deemed necessary to achieve statistical confidence, provided all of the data is reported. We further recommend the test method permit exclusion of outliers directly attributable to test equipment errors. We do not believe cases in which no fix is obtained should be excluded from the calculation of error statistics. One possible alternative in this event is to use the centroid of the serving cell (or sector in a sectorized system) as a surrogate fix for the purposes of calculating the location error. This treatment assumes that a Phase 1 quality fix (cell ID) is available as a fallback.

Measurements should be reported to a precision of one meter.

Because testing errors may be several meters and the typical total location error will be on the order of tens of meters, a measurement precision which is an order of magnitude better (i.e., one meter) is adequate for reporting purposes.

CHOICE OF MEASUREMENT LOCATIONS

A. General Observations

In considering the best overall method for determining measurement locations for compliance testing of E911 location systems, the following factors should be considered:

- Coverage Area
- Future Build-Out
- E911 Call Density
- Representation of Multipath Environments (Urban, Suburban, Rural, etc.)
- Repeatability
- Statistical Validity
- Location Accessibility
- Test Time Required

Since the E991 mandate applies to all wireless service providers, the method for measuring the location accuracy must apply generically to all types of systems. The items listed for consideration are independent of the type of system being tested and should lead to a fair determination of test locations.

B. Recommendations for Measurement Location Selection Method (Refer to Figure 2)

1. *Available measurement points should be determined by an overlay grid of the service area.*

   At the time of compliance testing for an individual carrier, a grid is defined over the license area currently in service. The test area should be defined as the area over which commercial service is available. The intersection points of the grid (grid points) define the available measurement points. The grid resolution is a parameter for further study.

2. *The total number of test points required would be determined as a percentage of the population in the service area, or a minimum number of test points, which ever is greater.*

   To balance the requirements for large and small carriers, the number of test points required should be based on a percentage of population in the service area, with a minimum threshold for all carriers to ensure statistical validity.

3. *The distribution of test points should be based on underlying population density.*

   Ideally, the distribution of test points would be based on the distribution of mobile E911 calls in the service area; however, this data is probably not readily available everywhere. We recommend use of population density data as a surrogate. The service area would be broken down by population density, as an overlay on the measurement grid. The population contained within an area of equal population density would define the number of test points required in that area, computed as: {(test point total) X [(area population)/(total population)]}. Population density contours can be derived from existing census information (or some other unbiased source).

4. *Test points should be chosen randomly from the available points.*

Once the number of test points required for a given area is computed, the actual location measurement points would then be chosen randomly from the available test points (grid points).

5. *Inaccessible measurement locations may be moved up to 20 m if necessary, or to the nearest adjacent point.*

The measurement location may be moved up to 20 m to allow for inaccessible grid points. In situations where this fails to yield an accessible test point, the test point may be relocated to the nearest accessible grid point.

6. *Future build out necessitates additional testing using the same criteria.*

As the service area is increased, additional areas should be tested within a specified time. Additional measurement data should be merged with previously collected data, to show overall compliance.

MEASUREMENT TECHNIQUES

The measurement technique used to verify positioning accuracy should faithfully mimic the actual operation of the deployed system when an E-911 call is placed.

By necessity, this will require a handset or handset simulator which can be programmed to set up an simulated E911 call, and which can record the time and location at which the call is made. It also seems appropriate that the portable/mobile hardware used to initiate the simulated E911 call, and the measurement process, should be capable of either manual or programmable call setup, depending on whether the measurement is being performed in a fixed/pedestrian or mobility mode.

Measurements should be made for a number of fixed locations as well as for several well-defined drive routes within each measurement area.

Measurements should be made for a number of fixed locations (with a pedestrian in random motion within a defined radial distance about the fixed location point), as well as for several well-defined drive routes within each measurement area. Each drive route should result in a statistically significant number of measurements performed on a roughly equal number of north/south and east/west streets, highways, etc. Since the measurements should be representative of the actual calls expected within each environment, the drive data should be measured at defined time intervals during each drive test. If this is done, and the drive velocity is consistent with the local traffic patterns, enough data points should be available from each drive route so that a good distribution of measurement velocities - representative of the typical velocities expected for each environment - should be obtained, and thus no constant-velocity measurements should need to be specified in the test standards.

Fixed location measurements should be made outdoors.

Fixed location measurements should be allocated between outdoor and in-building locations based upon a reliable statistic of the number of E-911 calls expected to be made from each environment.

Mobility measurements should be performed in two configurations.

Mobility measurements should be performed in two configurations; 1) handset in vehicle attached to a head simulator, and 2) handset in vehicle with an external (rooftop) antenna. The amount of data required to be taken for each configuration should be in proportion to the number of users associated with each configuration.

Antenna variables for each configuration should be defined and controlled.

The antenna orientation for the pedestrian measurements should be at an angle of 45º to 60º relative to zenith. A similar orientation should be used for the in-vehicle measurement set up. If an external mobility antenna configuration is defined, the antenna used, and placement on the vehicle, should be defined.

All technologies should be tested with a consistent test methodology and reporting of data.

The same test procedure should be used for all technologies including network based and handset based solutions. The results should all be presented in a standard format, i.e. a presentation of the cumulative CEP error probability showing compliance or non-compliance with the 67% and 95% requirement.

The use of predictive models (simulations) should be avoided as the primary means of verifying carrier compliance.

General predictive tools are not valid to verify compliance in a specific service area, and current site-specific simulation technology does not adequately reproduce the detailed multipath channel models necessary to faithfully predict performance at individual locations in a service area.

The latency between call setup, emergency call routing to a PSAP, and location fix, must be specified.

The maximum latency specified should be based upon the needs of public safety agencies and their determination as to what is acceptable for good E-911 response requirements. This limit should be consistent for all test locations and technical solutions.

AREAS FOR FURTHER STUDY

Several aspects of the verification methodology require further study and consensus from the industry in order to achieve a truly objective and unambiguous process. Some of these aspects for further study are:

- Granularity of population density contours to define regions of constant density.
- The total number of test points required and the number of measurements/point – This requires additional work regarding statistical confidence and a specific proposal for a method to determine the required confidence interval.
- Determine a specific proportion of fixed/mobile measurements or a standard method for obtaining this parameter.
- Determine a specific proportion of indoor/outdoor measurements or a standard method for obtaining this parameter.
- Determine the appropriate standard measurement point grid resolution.
- Determine a standard method for random selection of test points.
- Specify a standard head simulator.

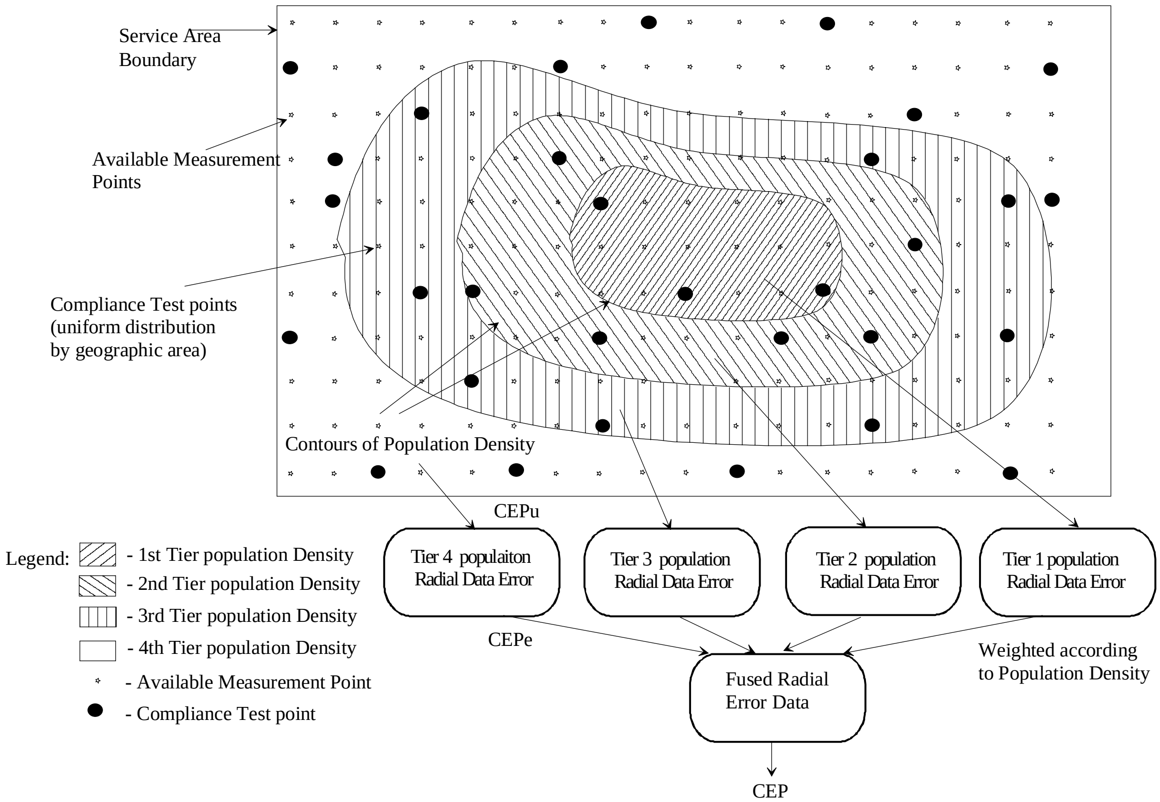

Figure 1: Uniform Measurement Density

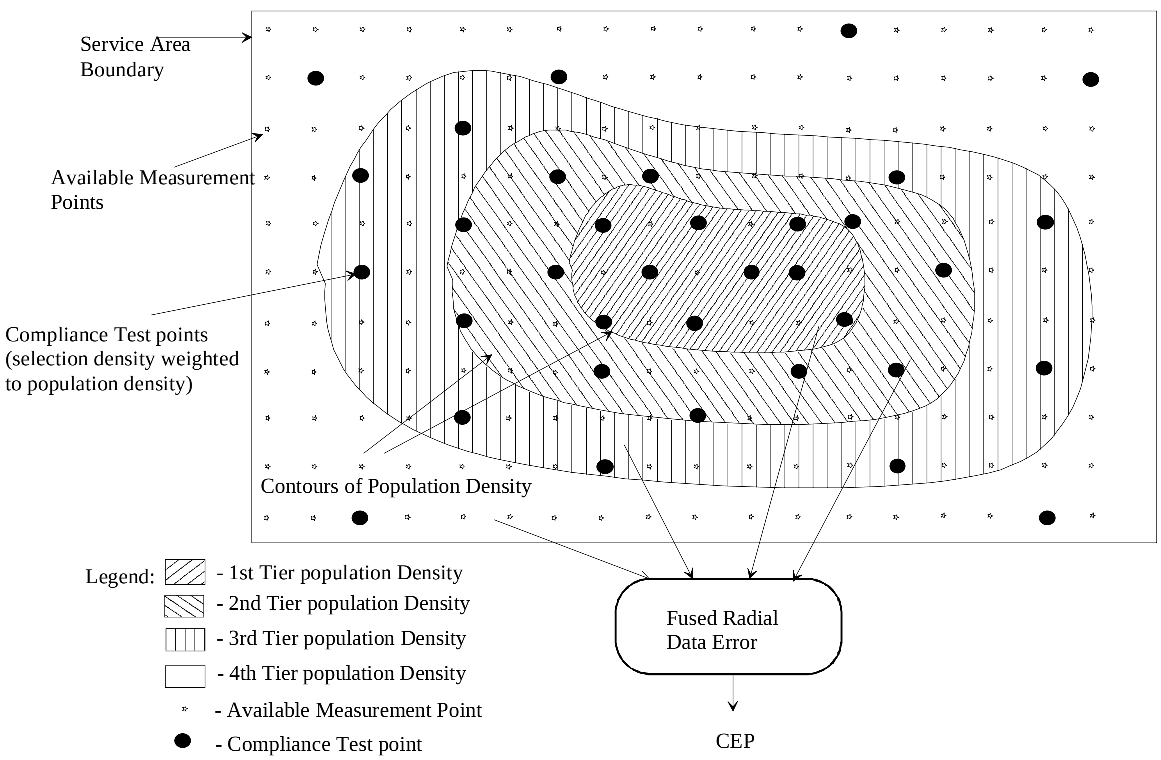

Figure 2: Measurement Density Varied By Population Density

Respectfully submitted,

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